Evaluating Radiative Fluxes in Current Reanalyses using CERES EBAF-TOA and EBAF-Surface Ed4.0

Hailan Wang[1], Norman G. Loeb[2], Wenying Su[2],
Fred G. Rose[1], Seiji Kato[2], David R. Doelling[2]

SSAI[1], NASA Langley Research Center[2]

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Introduction

- What is a reanalysis?
  - A consistent, global best estimate of atmospheric, land and ocean parameters obtained by combining model and observations in a data assimilation system
  - Widely used for various weather and climate studies
- Evaluation of reanalyses using observations:
  - In-situ (e.g. ARM, DYNAMO)
  - Satellite-based (e.g. CERES EBAF-TOA)
    - e.g. Wong (2014), Dolinar *et al*. (2016)

Data and Methodology

- CERES Ed4.0
  - EBAF-TOA; EBAF-Surface; SSF1deg Lite
- Reanalyses
  - MERRA-2; ERA-Interim; ERA5
- Analysis
  - Period
    - Jan2010-Aug2016
  - Evaluation:
    - Mean climate
    - Year-to-year variation

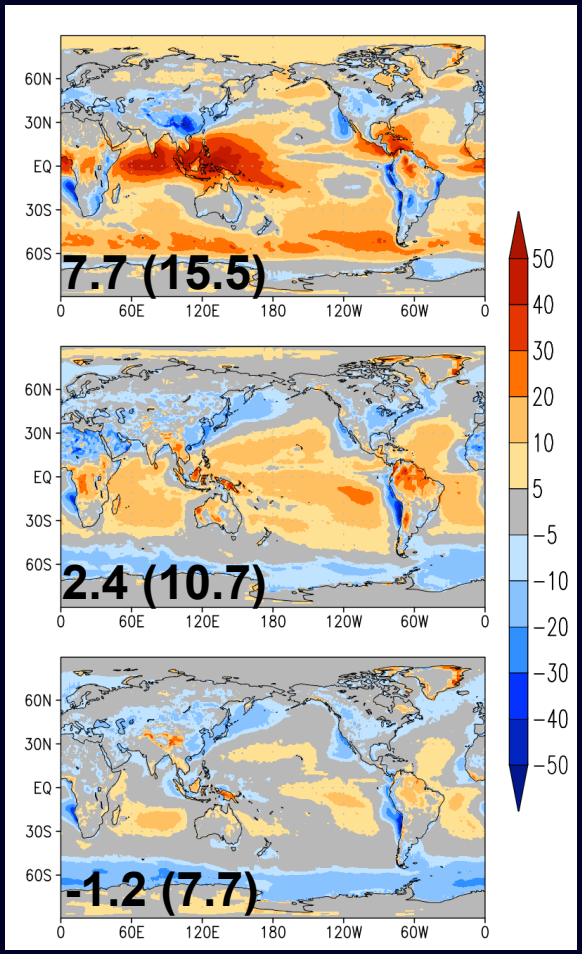
Mean Climate (2010-2015): TOA

SWall↑

MERRA-2

ERA-I

ERA5



- Diverse performance among the reanalyses;

Mean Climate (2010-2015): TOA

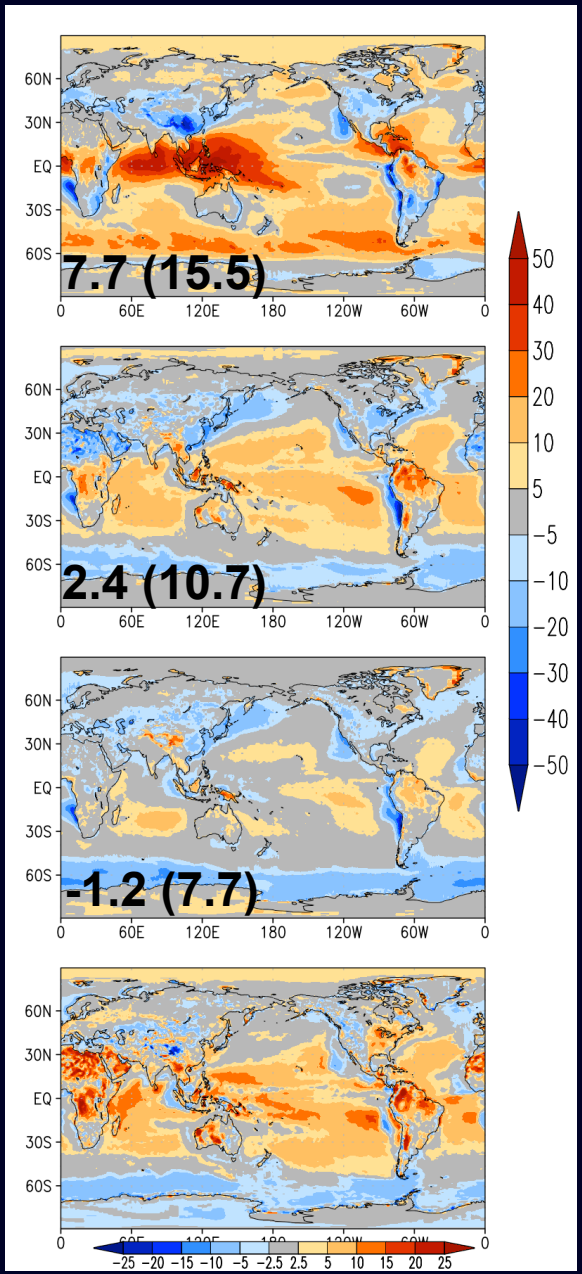
SWall↑

MERRA-2

ERA-I

ERA5

ERA-I vs. ERA5



- Diverse performance among the reanalyses;
- ERA5 shows considerable improvement over ERA-I in much of the tropics and subtropics.

Closeness:

|ERA-I − CERES| − |ERA5 − CERES|

ERA5 closer/better; ERA5 worse

Mean Climate (2010-2015): TOA

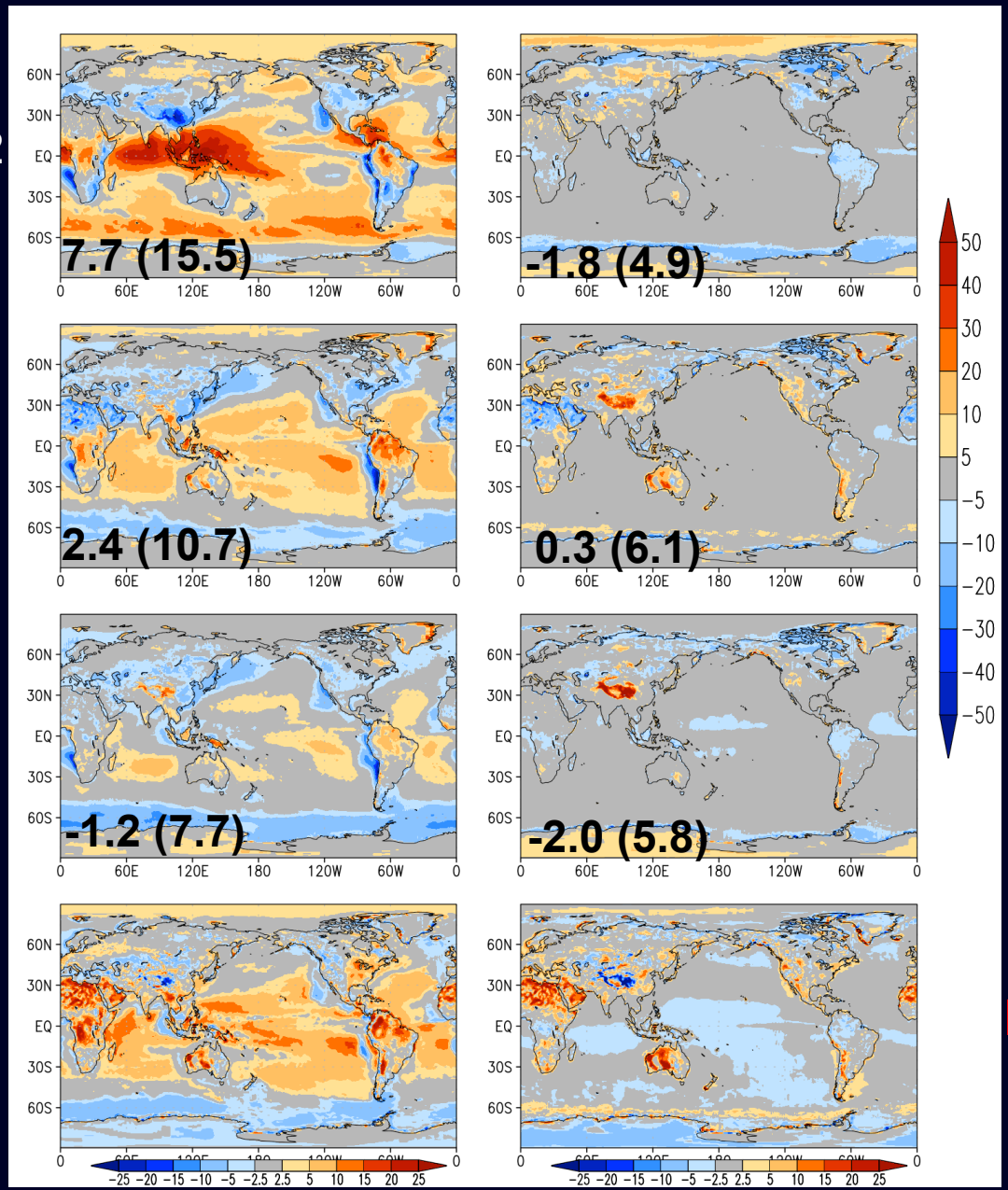
SWall↑ SWclr↑

MERRA-2

ERA-I

ERA5

ERA-I vs. ERA5



ERA5 better; ERA5 worse

Mean Climate (2010-2015): TOA

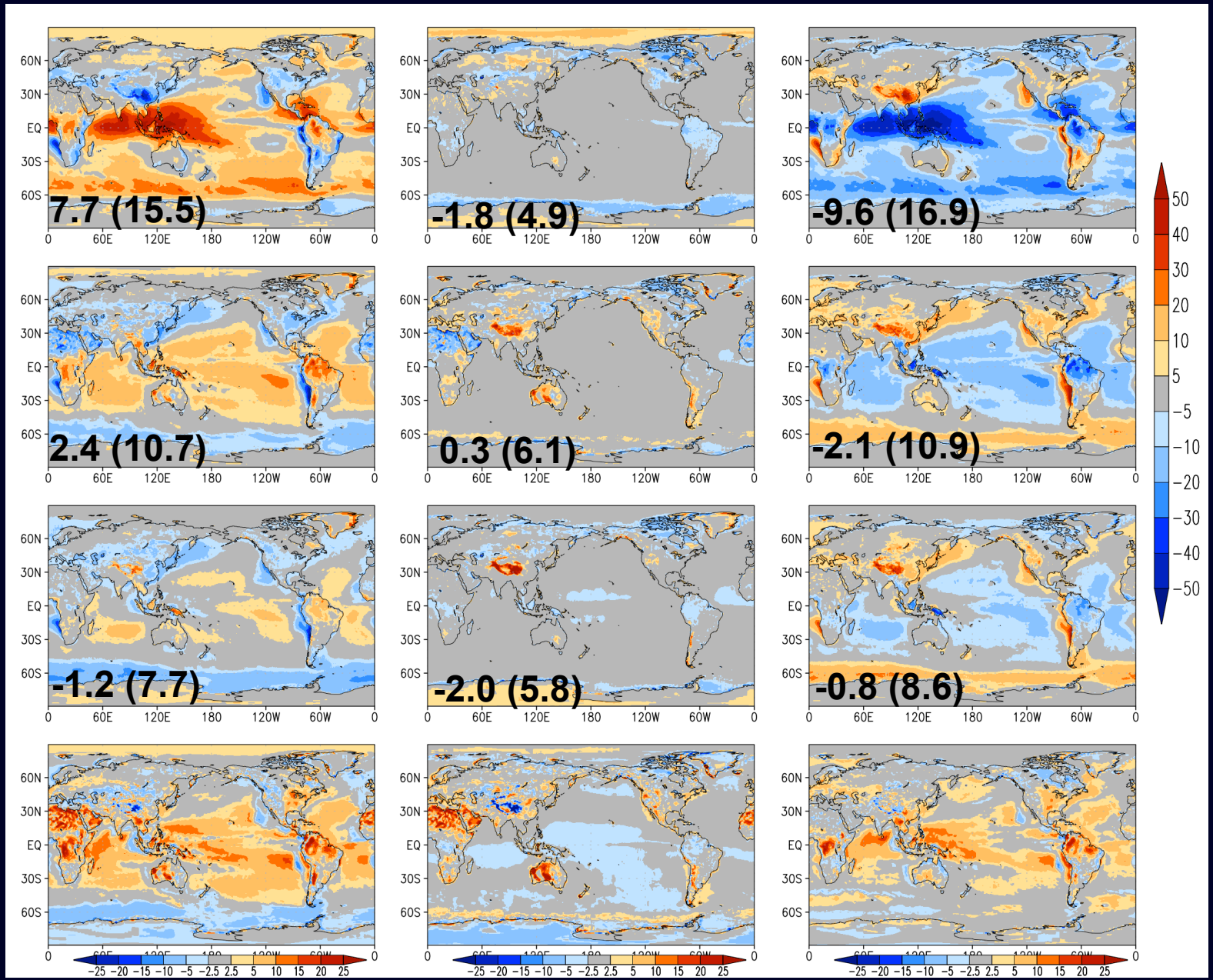
SWall↑ SWclr↑ SW CRE

MERRA-2

ERA-I

ERA5

ERA-I vs. ERA5



Mean Climate (2010-2015): TOA

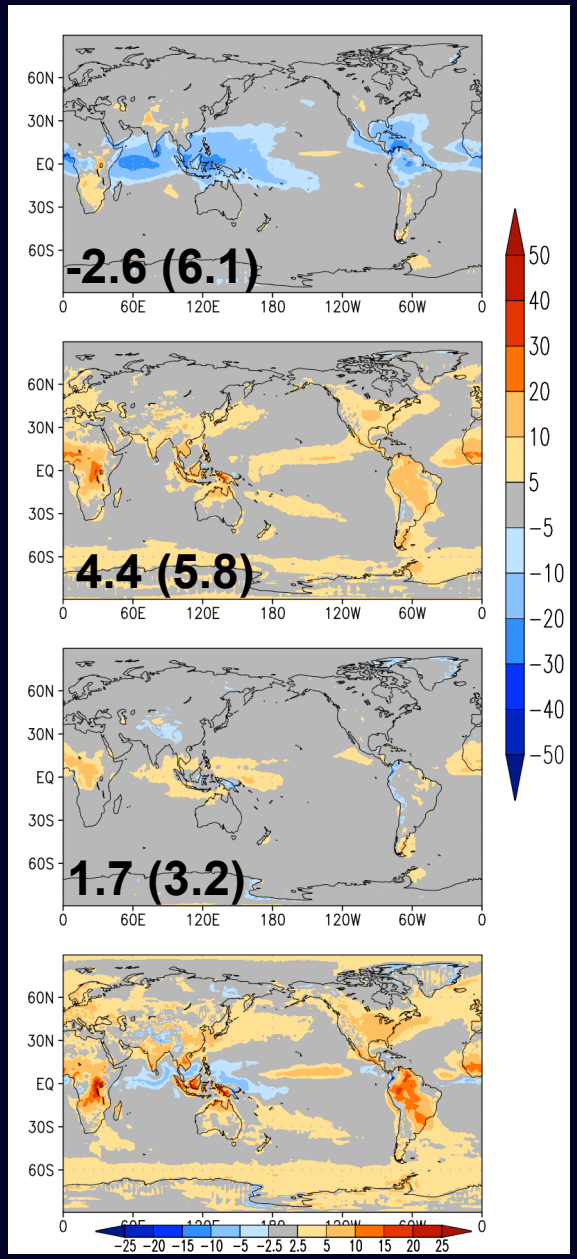
OLRall

MERRA-2

ERA-I

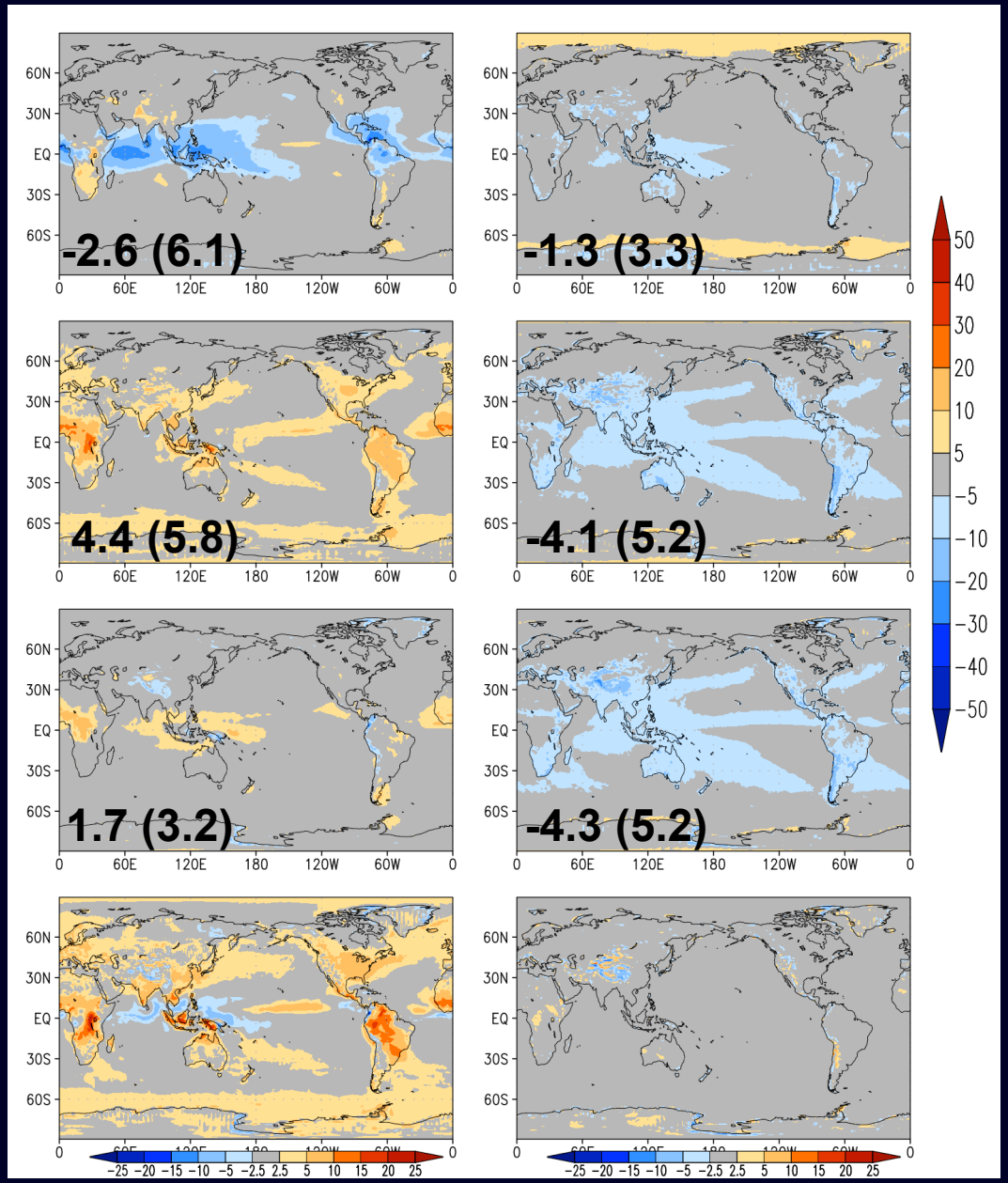
ERA5

ERA-I vs. ERA5



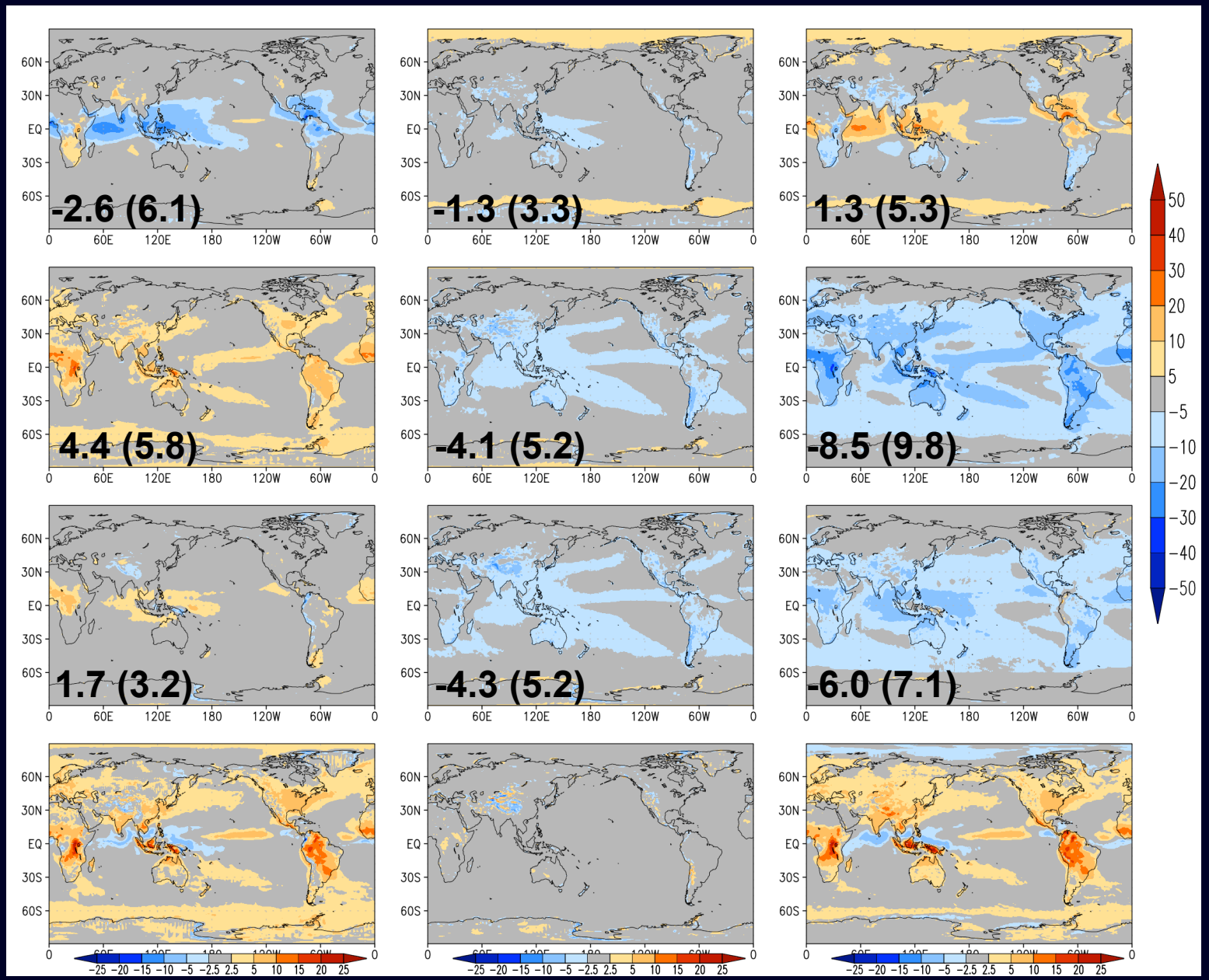
- Diverse performance among reanalyses;
- ERA5 shows substantial improvement over ERA-I:
  - ITCZ, SPCZ, land, NH storm track regions

Mean Climate (2010-2015): TOA

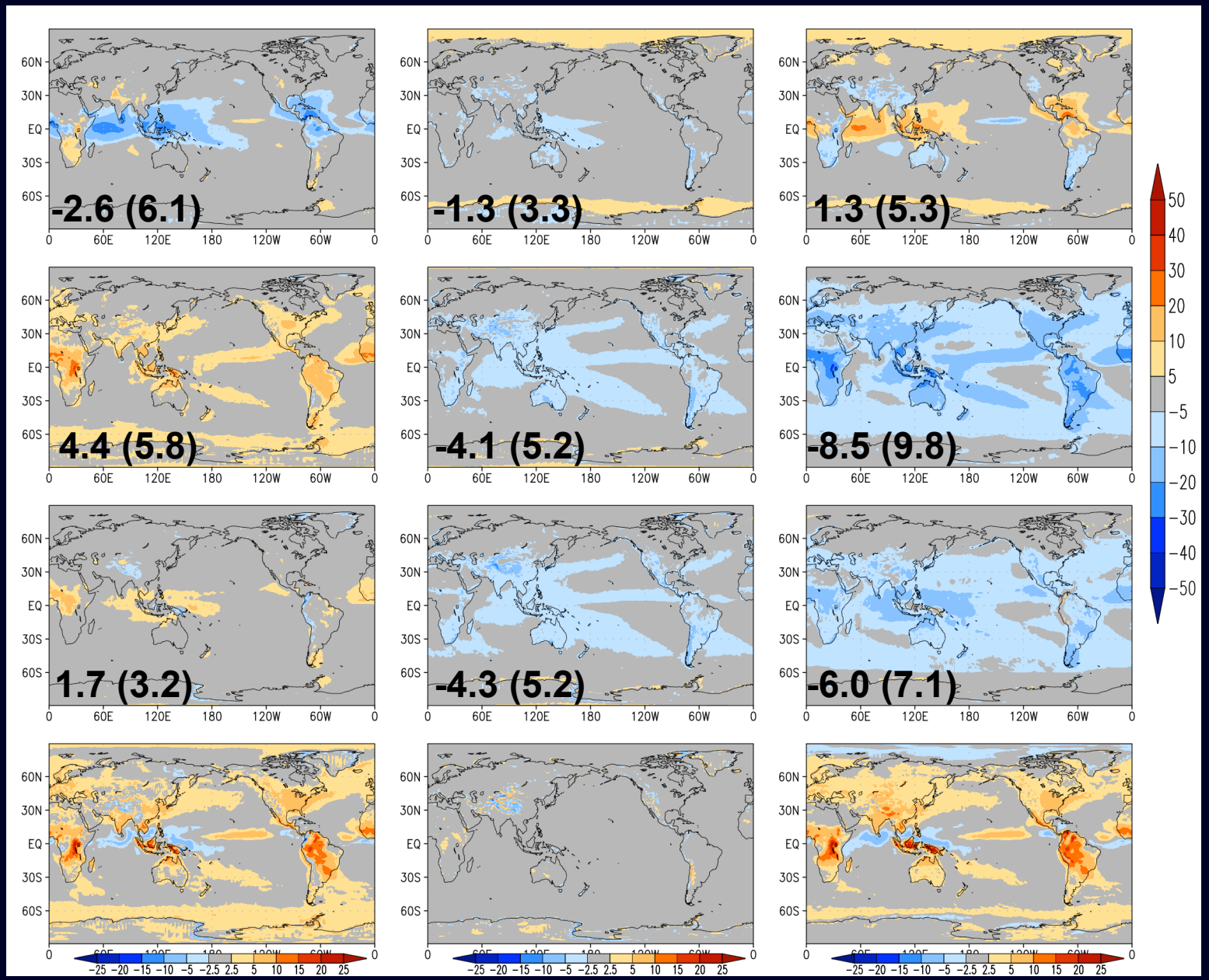


- Reanalyses underestimate OLRclr over deep convective regions.

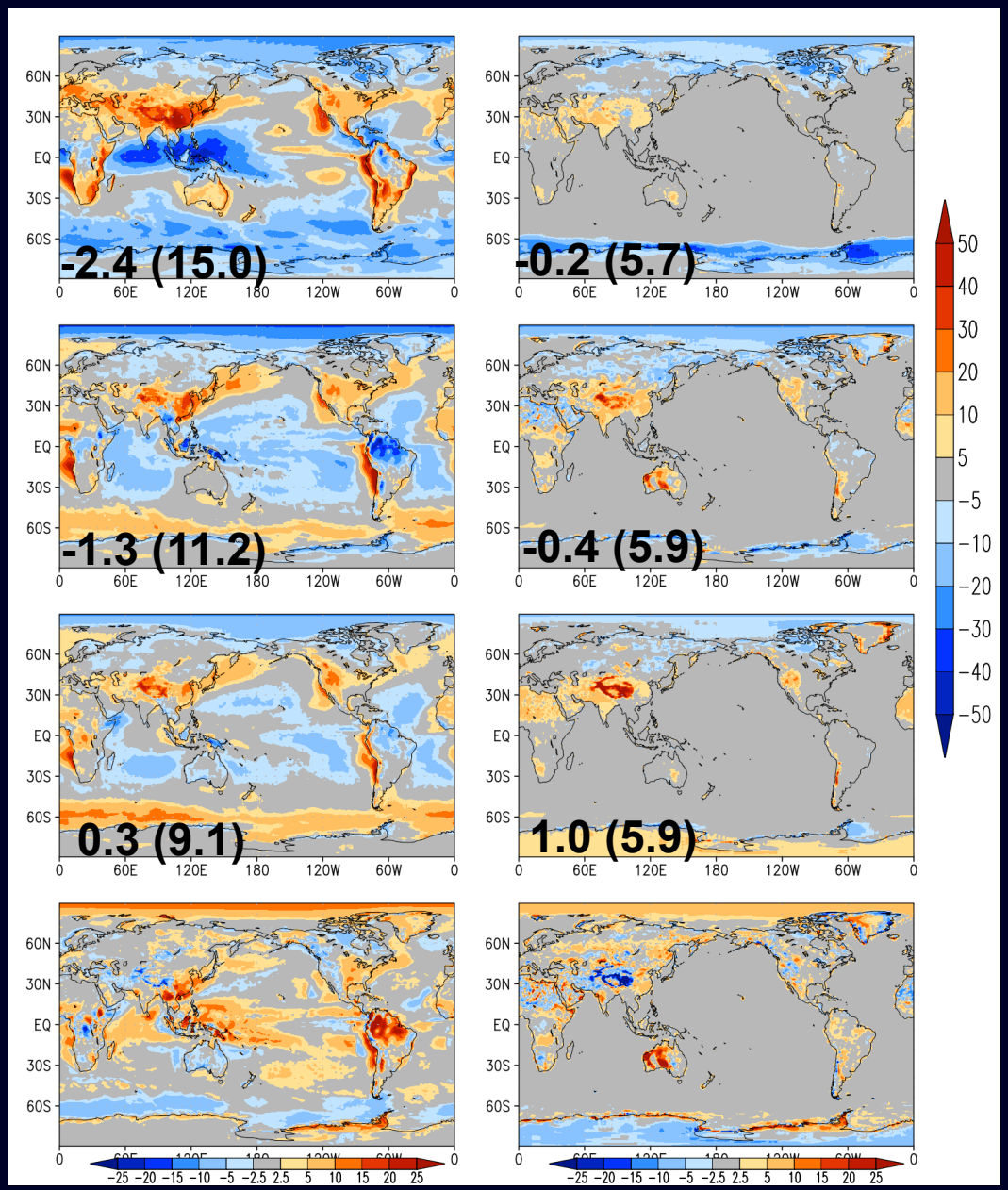
Mean Climate (2010-2015): TOA



Mean Climate (2010-2015): TOA

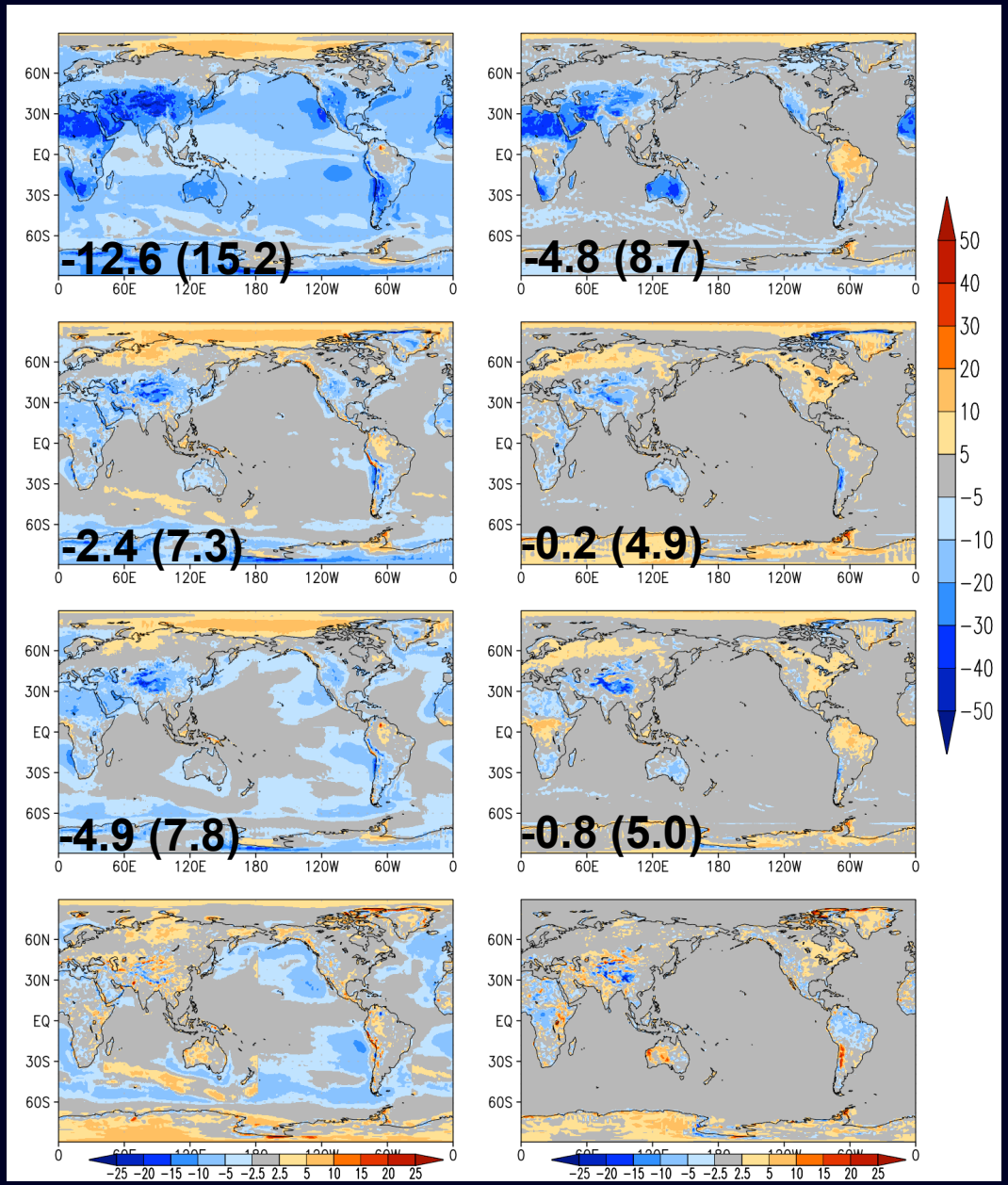


Mean Climate (2010-2015): Surface



- Reanalysis biases in Surface SWall↓ reflect those in TOA SWall↑

Mean Climate (2010-2015): Surface

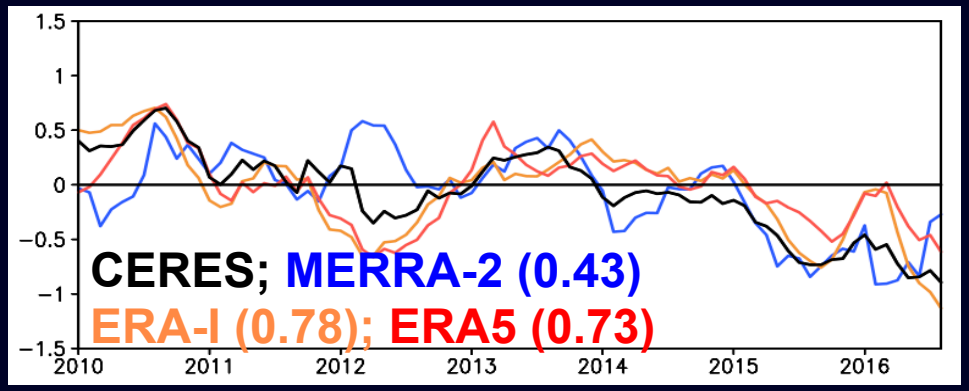


- Reanalyses underestimate Surface LWall↓

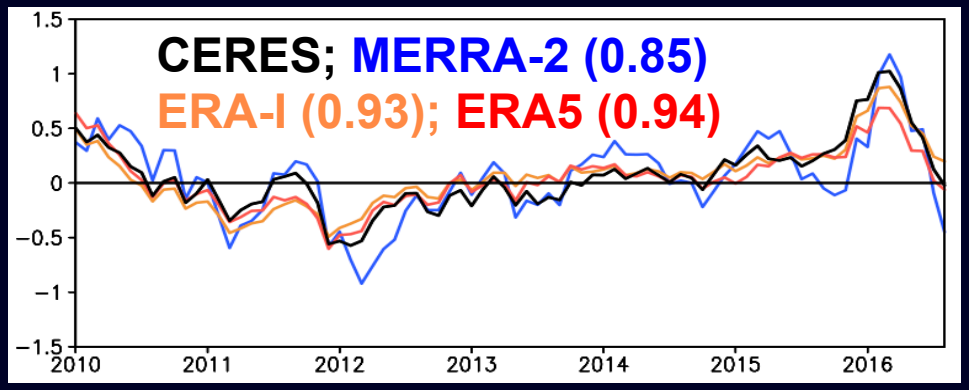
Year-to-year Variation

Global Mean of Deseasonalized Anomalies (5Mon RunMean)

TOA SWall↑



TOA OLRall



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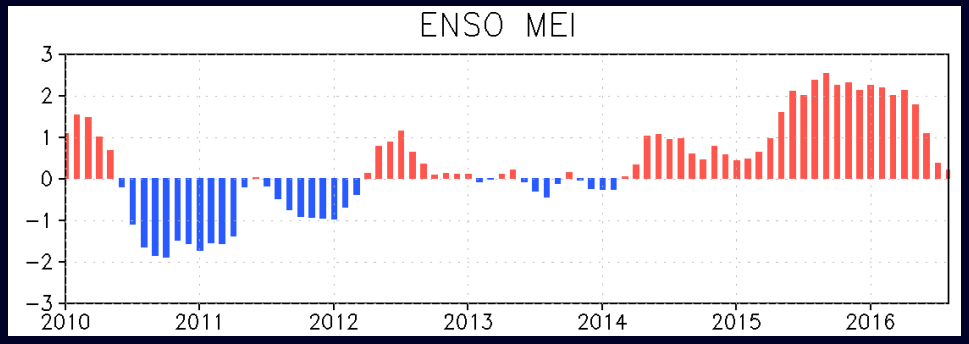
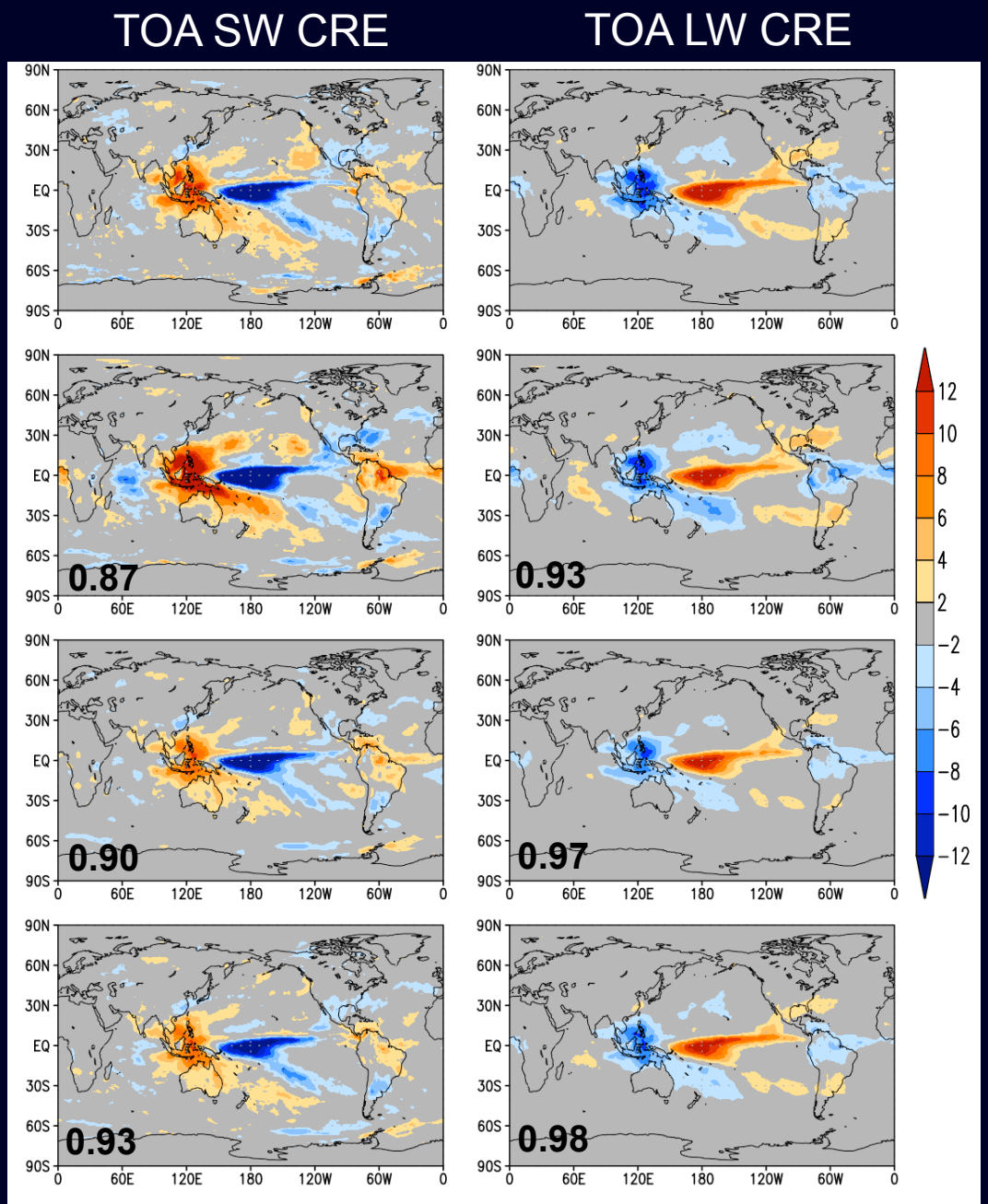


- Better performance in LW than in SW;
- A considerable portion of the interannual variation is contributed by ENSO.

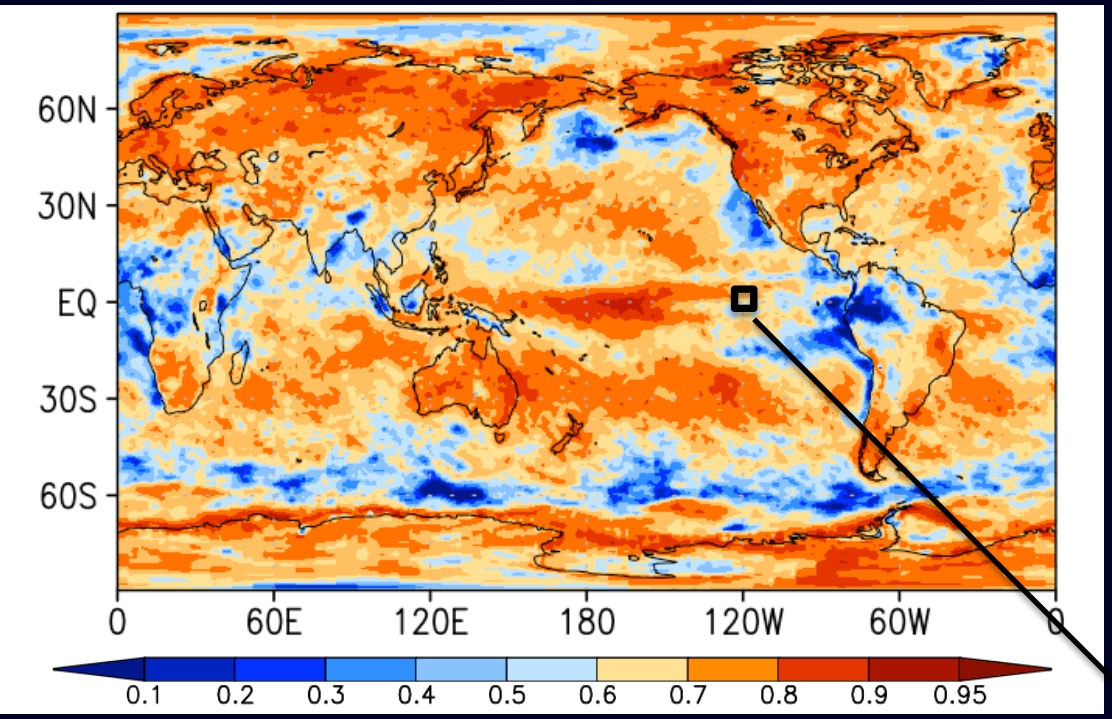
Year-to-year Variation: ENSO Anomalies



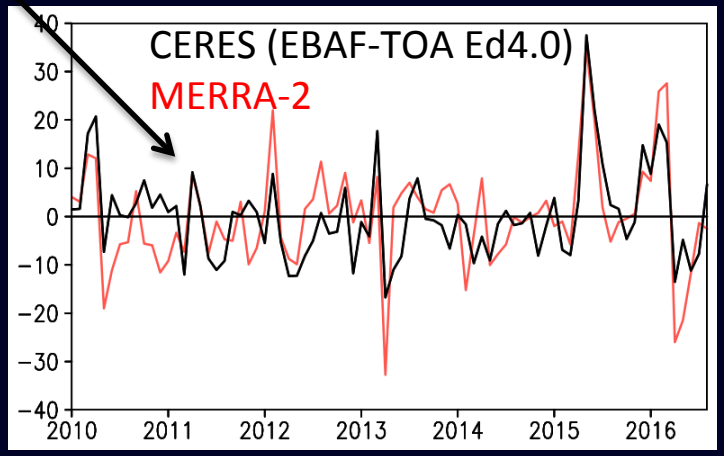
Very good agreement

Year-to-year Variation: Temporal Correlation

TOA SWall↑: tcorr (CERES, MERRA-2)



TOA SWall↑ at 120°W0°N
tcorr (CERES, MERRA-2): 0.70



Year-to-year Variation: Temporal Correlation

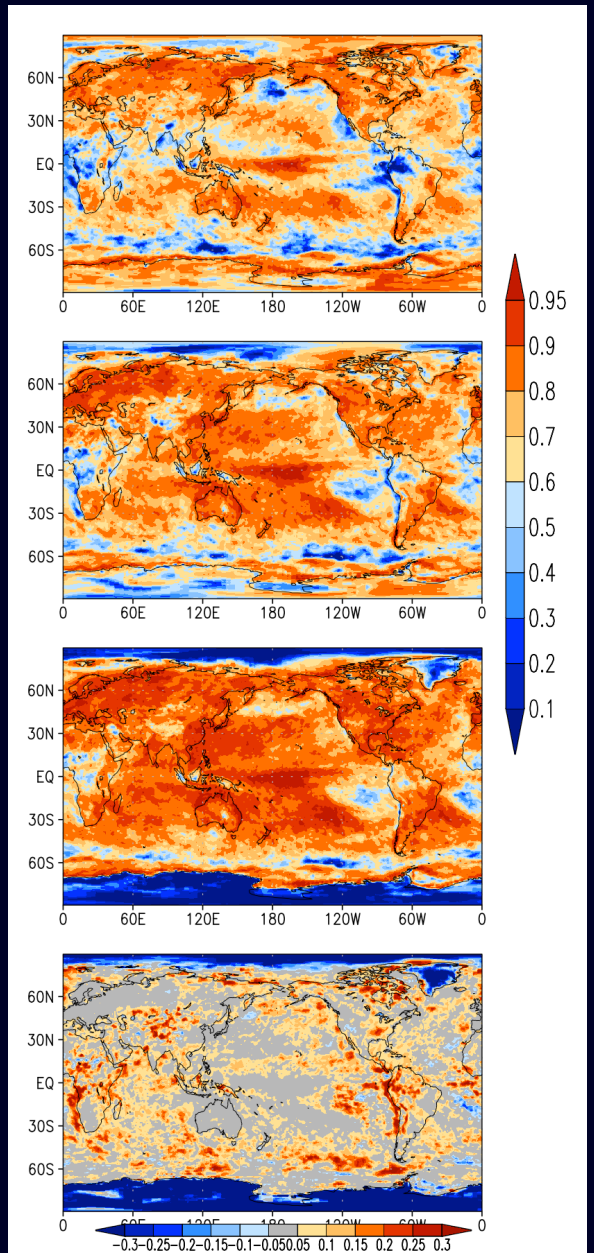
TOA SWall↑

MERRA-2

ERA-I

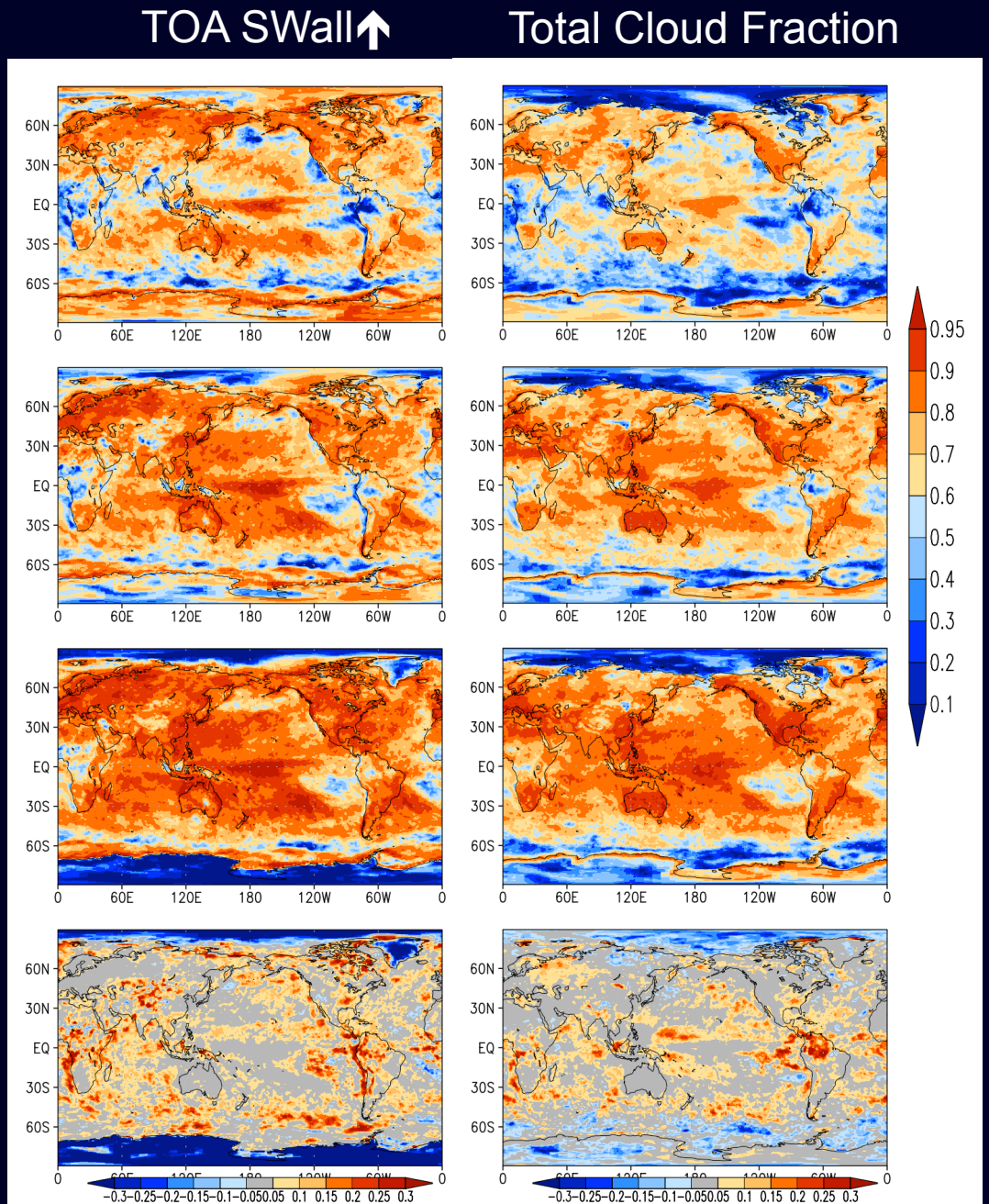
ERA5

ERA5 minus ERA-I



- Reanalyses are subject to the performance of their assimilating models, which are challenged in simulating processes over:
  - Tropical land
  - Subtropical stratocumulus regions
  - Extratropical oceans
  - Polar regions
- ERA5 shows considerable improvement over ERA-I in nonpolar regions.

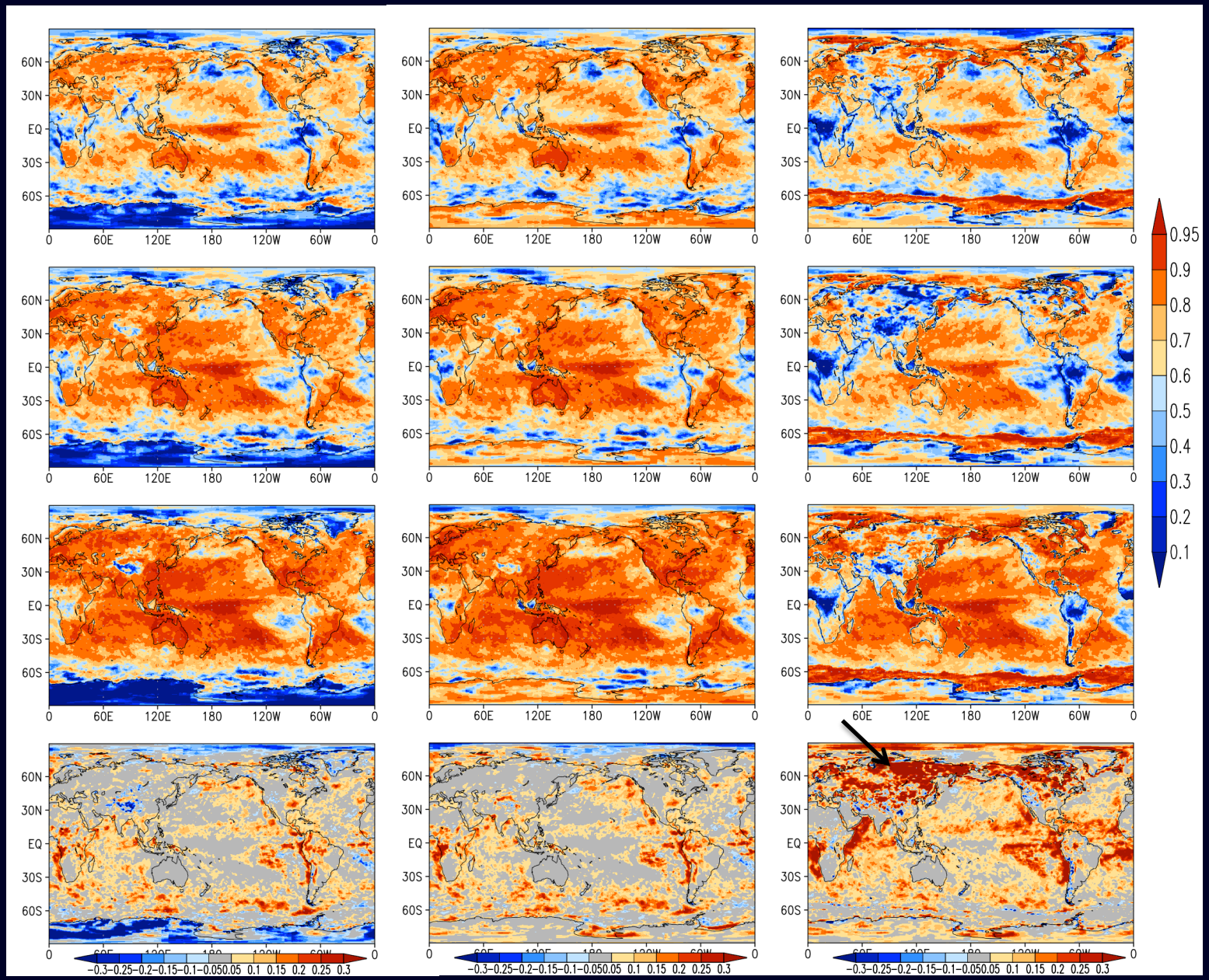
Year-to-year Variation: Temporal Correlation



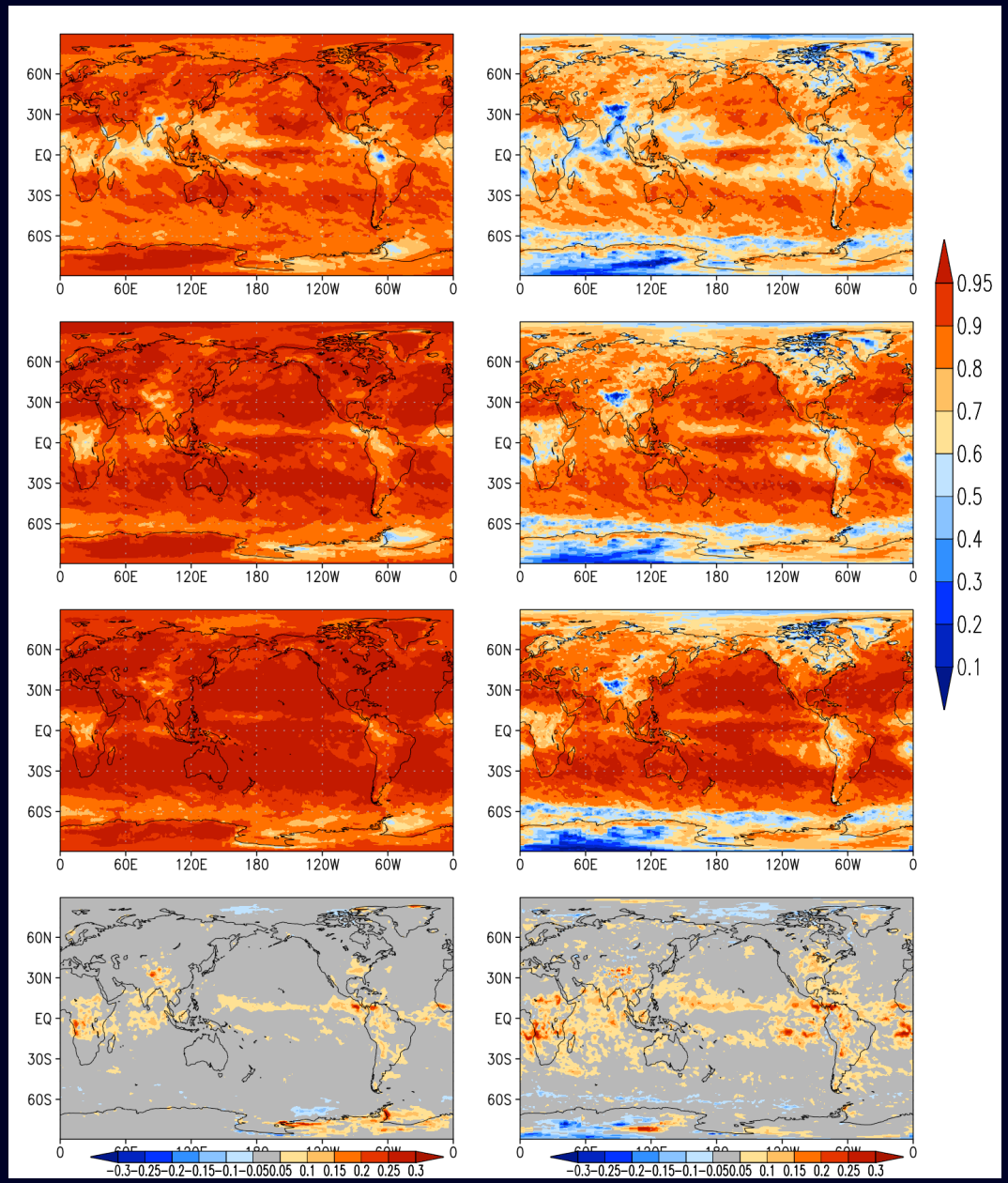
Regional biases in TOA SWall↑ are:

- closely associated with those in clouds;
- similarly shown in TOA SW CRE and surface SWall↓, SWall↑, SW CRE.

Year-to-year Variation: Temporal Correlation

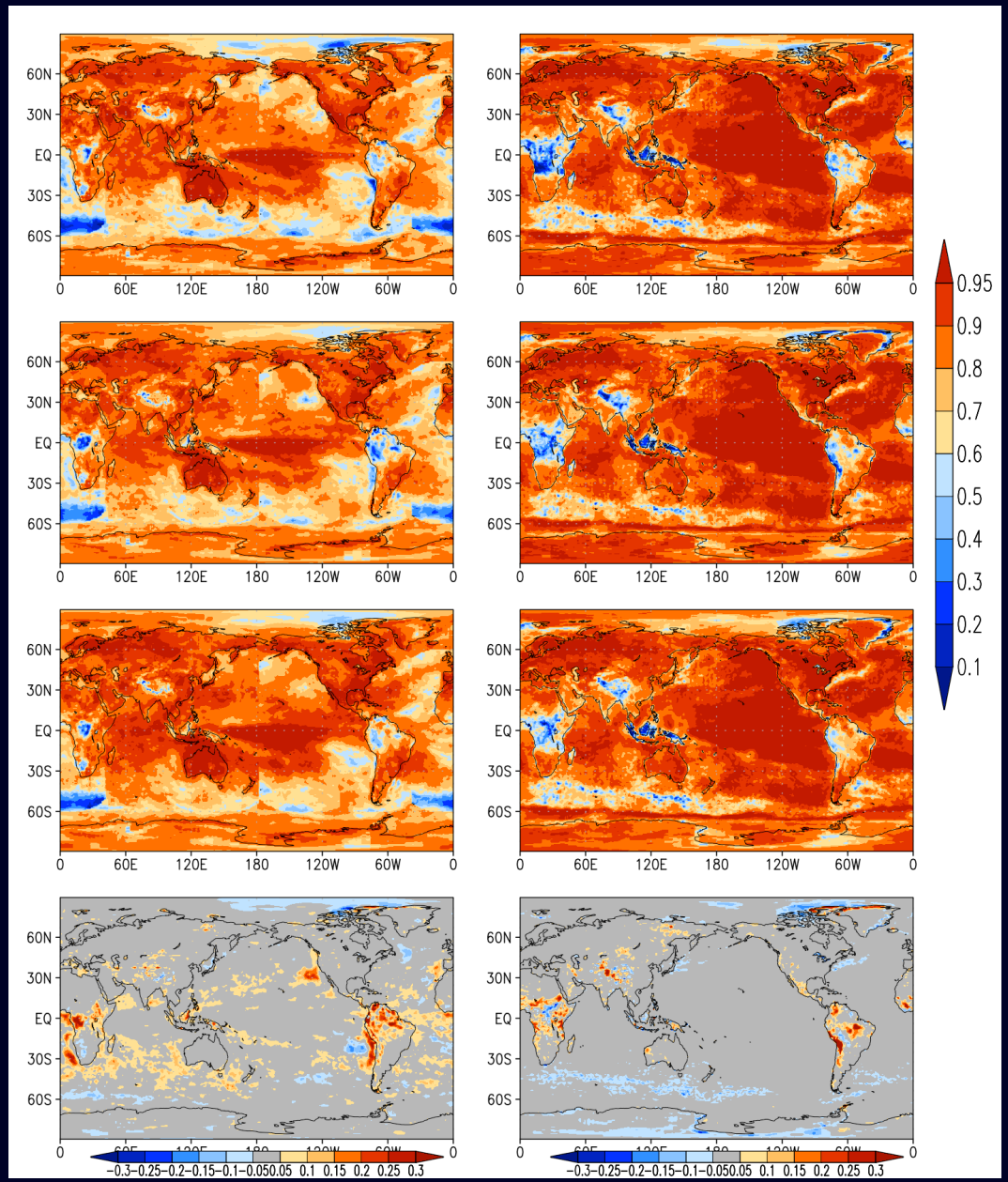


Year-to-year Variation: Temporal Correlation



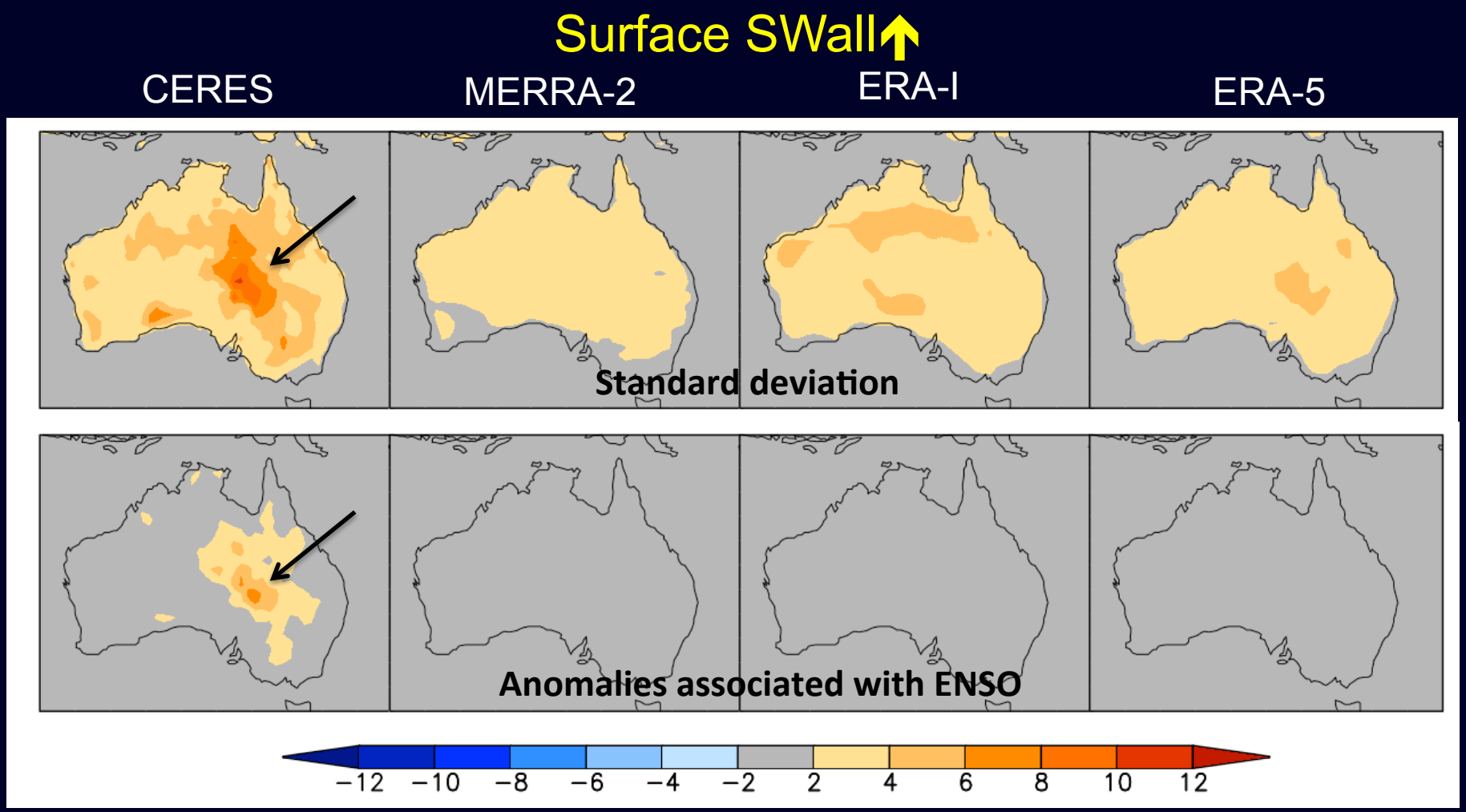
- LW better than SW;
- ERA5 is greater than ERA-I;
- Lower corr is seen over tropical deep convective land regions & Tibet.

Year-to-year Variation: Temporal Correlation



- LW better than SW;
- ERA5 is greater than ERA-I;
- Lower corr is seen over tropical deep convective land regions & Tibet.

Year-to-year Variation: Standard Deviation



- Current reanalyses do not adequately capture observed surface albedo changes (e.g. associated with vegetation changes), as their land albedo is often based on a monthly climatology (Loeb *et al*. 2016).

Summary

- Current reanalyses:
  - well capture TOA radiative flux variations associated with ENSO as well as those over the NH land area,
  - show greater performance in LW than in SW.

- Current reanalyses are subject to the performance of their assimilating models in simulating cloud and radiative processes. Challenges remain over:
  - tropical deep convective regions, especially tropical land;
  - subtropical stratocumulus regions;
  - extratropical oceans;
  - Land surface albedo.

- ERA5 shows substantial improvement over ERA-Interim.